Claims

1. Method for calibrating a camera-laser-unit (1) in respect to at least one calibration-object (12) disposed at a given position and orientation in a three-dimensional space (13), wherein the camera-laser-unit (1) comprises at least one laser (4) and at least one camera (3), wherein the laser (4) and the camera (3) are disposed in a given distance to one another and an optical axis (9) of the laser (4) and an optical axis (8) of the camera (3) include a given angle (α), and wherein the camera-laser-unit (1) is adapted to record the location, form and/or dimensions of a measurement-object (5), comprising the steps of:

   a. selecting a calibration-object (12) comprising at least two plains (14, 15) disposed in a given angle (β) to each other and provided with a given non-coplanar calibration-pattern;

   b. disposing the calibration-object (12) in respect to the camera-laser-unit (1) in a given position and orientation in the three-dimensional space (13), wherein the orientation of the calibration-object (12) is such that light emitted by the laser (4) is visible for the camera (3) on at least two plains (14, 15) of the calibration-object (12);

c. calibrating the camera (3) in respect to the calibration-object (12) using a Tsai algorithm;

d. activating the laser (4) so it emits light (11) visible on the at least two plains (14, 15) of the calibration-object (12);

e. recording the light (11) on the plains (14, 15) by the camera (3);

f. determining the laser-properties from the light (11) recorded by the camera (3); and

g. calibrating the laser (4) according to the determined laser-properties.

2. Method according to claim 1, characterized in that calibrating the laser (4) comprises the step of:

a. definition of a relative position and orientation of the laser (4) in respect to a coordinate frame (19) associated with the calibration-object (12), wherein said coordinate frame (19) is in a given position and orientation in the three-dimensional space (13).

3. Method according to claim 1 or 2, characterized in that

a. the light (11) emitted by the laser (4) is visible on the plains (14, 15) of the calibration-object (12) as a line (11a, 11b) on each plain (14, 15),

the lines (11a, 11b) intersecting on a contact line of the two plains (14, 15); and

b. the laser-properties are determined from the lines (11a, 11b) recorded by the camera (3) by means of a line detection algorithm.

4. Method according to one of the claims 1 to 3, characterized in that

a. the light (11) emitted by the laser (4) is visible on the plains (14, 15) of the calibration-object (12) as a line (11a, 11b) on each plain (14, 15), the lines (11a, 11b) intersecting on a contact line of the two plains (14, 15);

b. a laser-plain is defined by the optical axis (9) of the laser (4) and the lines (11a, 11b) visible on the plains (14, 15) of the calibration-object (12); and

c. in order to calibrate the laser (4) according to the determined laser-properties, the position and orientation of the laser-plain in respect to a coordinate frame (19) associated with the calibration-object (12) is defined.

5. Method according to one of the claims 1 to 4, characterized in that calibrating the camera (3) comprises the step of:

a. definition of a relative position and orientation of the camera (3) in respect to a coordinate frame (19) associated with the calibration-object (12), wherein said coordinate frame (19) is in a given position and orientation in the three-dimensional space (13).

6. Method according to one of the claims 1 to 5, characterized in that a transformation matrix is defined depending on the relative position and orientation of the camera (3) in respect to a coordinate frame (19) associated with the calibration-object (12), the relative position and orientation of the laser (4) in respect to said coordinate frame (19), and optionally on internal camera parameters.

7. Method according to one of the claims 1 to 6, characterized in that the camera-laser-unit (1) to be calibrated is grasped by an industrial robot and disposed in respect to the calibration-object (12) in a given position and orientation in the three-dimensional space (13), wherein the orientation of the camera-laser-unit (1) is such that light (11) emitted by the laser (4) is visible for the camera (3) on at least two plains (14, 15) of the calibration-object (12).

8. Calibration-object (12) used for calibrating a camera-laser-unit (1) and disposed at a given position and orientation in a three-dimensional space (13), wherein

the camera-laser-unit (1) comprises at least one laser (4) and at least one camera (3), wherein the laser (4) and the camera (3) are disposed in a given distance and an optical axis (9) of the laser (4) and an optical axis (8) of the camera (3) have a given angle (α), and wherein the camera-laser-unit (1) is adapted to record the location, form and/or dimensions of a measurement-object (5), **characterized in that** the calibration-object (12) comprises two plains (14, 15) disposed in a given angle (β) to each other, provided with a non-coplanar calibration-pattern on each plain (14, 15) comprising an array of features (17), and the calibration-object (12) is used for calibration of the camera (3) as well as for calibration of the laser (4).

9. Calibration-object (12) according to claim 8, characterized in that the angle (β) between the two plains (14, 15) of the calibration-object (12) is a right angle.

10. Calibration-object (12) according to claim 8 or 9, characterized in that the features (17) of the calibration-pattern are designed as recesses, in particular as cavities having a circular cross section.

11. Calibration-object (12) according to claim 8 or 9, characterized in that the features (17) of the

calibration-pattern comprise prints on the plains (14, 15).